Computed Tomography (CT) of Bowel and Mesenteric Injury in Blunt Abdominal Trauma: A Pictorial Essay

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SUMMARY

Computed tomography (CT) is currently the diagnostic modality of choice in the evaluation of clinically stable patients with blunt abdominal trauma, including the assessment of blunt bowel and mesenteric injuries. CT signs of bowel and/or mesenteric injuries are bowel wall defect, free air, oral contrast material extravasation, extravasation of contrast material from mesenteric vessels, mesenteric vascular beading, abrupt termination of mesenteric vessels, focal bowel wall thickening, mesenteric fat stranding, mesenteric haematoma and intraperitoneal or retroperitoneal fluid. This pictorial essay illustrates CT features of bowel and/or mesenteric injuries in patients with blunt abdominal trauma. Pitfalls in interpretation of images are emphasized in proven cases.

KEY WORDS:
Bowel and mesenteric injury, Computed tomography, Blunt abdominal trauma

INTRODUCTION

Bowel and/or mesenteric injuries (BMI) are uncommon and found in about 1% of all blunt abdominal trauma patients undergoing CT evaluation[1]. It is detected in approximately 3-5% of patients undergoing laparotomy for blunt abdominal trauma[2]. Clinical and radiological diagnoses of bowel and/or mesenteric injuries are difficult as compared to injuries to other visceral organs. Clinical signs of bowel injuries such as abdominal tenderness, rigidity, absent bowel tones are present in less than 50% of patients[3]. Clinical evaluation is more difficult in polytrauma patients especially those with head and spinal cord injuries[4]. Delay in diagnosis of bowel and/ mesenteric injuries results in increased morbidity and mortality[2,5,6].

There are various diagnostic tests used in assessment of patients with blunt abdominal trauma to detect bowel and/or mesenteric injuries. These include diagnostic peritoneal lavage (DPL), ultrasonography (US) and computed tomography (CT). DPL has sensitivity greater than 90% for the detection of haemoperitoneum but it is not specific[7]. DPL fails to indicate the source of abdominal haemorrhage or presence of retroperitoneal bowel injuries. DPL may miss up to 10% of bowel perforation[8]. Another well-known deficiencies of DPL include its inability to differentiate between significant from non-significant haemoperitoneum[9]. This has lead to non-therapeutic laparotomy in up to 1/3 of patients with positive DPL[10]. Even though reported as safe in many papers, DPL is an invasive procedure with its associated risks[11]. It is also rarely performed in paediatric patients. If it is performed before CT scan, it can compromise the interpretation of the CT study since air and fluid may be present within the peritoneal cavity as a result of the lavage. Ultrasonography is inaccurate in the diagnosis of bowel perforation[7]. Focused abdominal sonography for trauma (FAST) yields a sensitivity of 86% to 98% for the detection of free intraabdominal fluid but is less specific with regard to organ injury[12].

CT is more sensitive and specific than DPL, FAST and clinical examination for the diagnosis of bowel and mesenteric injuries. It has become the diagnostic test of choice for the evaluation of haemodynamically stable patients with possible bowel injuries[13]. Previous studies reported MSCT has sensitivities ranging from 87% to 95% and specificity of 84% to 100% for the diagnosis of bowel and mesenteric injuries[14-16]. Major technical advances in MSCT had increased its accuracy and sensitivity in detection injuries as well as reduced the time spent to complete the study.

This article illustrates CT appearances and signs of bowel and/or mesenteric injuries caused by blunt abdominal trauma. In 2008 and 2009, there were 45 patients who had laparotomies for blunt abdominal injury in our hospital. CT scans of these cases were retrospectively reviewed and correlation with surgical findings was made. The CT findings are with reference to 13 patients with surgically significant bowel and/or mesenteric injuries, 5 patients with nonsurgically important bowel and/or mesenteric injuries and few patients with shock bowel syndrome. The CT features that help to differentiate these injuries and pitfalls in interpretation are emphasized in these proven cases.

All our patients were scanned using a four-slice MSCT scanner; Somatom Siemens Volume Zoom (Siemens Medical Systems, Erlangen Germany). The slice width was 10mm, collimation of 2.5mm, rotation time was 0.75s, table feed of 15 mm and 3 mm reconstruction interval. The CT was performed from the dome of the diaphragm to the symphysis pubis. Pre- and post-contrast scans were routinely performed and patients received 2ml/kg of intravenous contrast media (Iohexol 300 mg I/ml). Oral contrast was not routinely administered in our patients. The post contrast CT scans were acquired during portal venous phase, approximately 80 seconds after contrast injection. When necessary, sagital and

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coronal images were acquired using multiplanar reconstruction (MPR) technique.

CT FINDINGS OF BOWEL/AND OR MESENTERIC INJURIES

There are numerous CT signs of bowel and mesenteric injury secondary to blunt trauma that has been described in the literature[17]. The main goal in evaluating these signs is to distinguish significant bowel and/or mesenteric injury that require surgical intervention from those that can be managed conservatively[18].

Surgically important bowel and/or mesenteric injuries that need surgical intervention include full-thickness perforation, seromuscular tear, devascularized bowels, active mesenteric bleeding and mesenteric injury resulting in bowel ischaemia. Injuries that do not require surgical intervention include serosal tear of bowel, bowel wall haematoma without a full thickness tear and mesenteric haematomas without active bleeding.

Reproducible results can be achieved using a variety of CT criteria[14,19]. Specific signs for bowel and/or mesenteric injuries on CT scan include bowel wall defect, free air, oral contrast material extravasation, extravasation of contrast material from mesenteric vessels, evidence of bowel infarctions, vascular beading and abrupt termination of mesenteric vessels. Less specific signs are focal bowel wall thickening, mesenteric fat stranding, focal mesenteric haematoma and intraperitoneal or retroperitoneal fluid.

However, CT criteria to differentiate significant from nonsignificant bowel and/or mesenteric injuries may overlap and no one CT criterion is sensitive or specific for bowel and/or mesenteric injury[19,20]. Combination of these CT findings is important for an accurate diagnosis. Correlation with clinical features and CT reevaluation is necessary when the findings are only nonspecific for bowel and mesenteric injuries[18].

FREE INTRAPERITONEAL AND RETROPERITONEAL FLUID

The presence of free fluid is one of the most sensitive but indirect features of bowel and mesenteric injuries (Figure 1). It is reported to occur in 93% of patients with bowel and/or mesenteric injury[2]. The free fluid may be of low attenuation representing bowel contents or of intermediate to high attenuation due to acute haemorrhage or oral contrast material extravasation. Without visible solid organ injury, the presence of a moderate or large amount of free fluid is a useful sign of bowel and/or mesenteric injury and is a strong indicator for exploratory laparotomy[7,16,21]. On the other hand, lack or minimal intraperitoneal fluid at CT has a high negative predictive value in the exclusion of surgically important bowel and/or mesenteric injury[22].

Fluid collection adjacent to bowels located in the retroperitoneum is a fairly specific sign and can be useful to localize the injury at the adjacent site (Figure 2). This is because retroperitoneal fluid is restricted and tends to localize at the site of injury. In contrast, intraperitoneal fluid can flow freely in the peritoneum into the most dependant spaces such as the deep pelvis[23].

EXTRA-LUMINAL AIR (PNEUMOPERITONEUM)

Free air in the peritoneum seen on CT scan is highly suggestive but not pathognomonic of bowel perforation (Figure 3). It is a relatively specific sign but is seen in only 20-55% of patients[2,24]. Free air is not observed in majority of patients with full-thickness bowel injury on CT scans at admission16. In cases of perforation especially involving the small bowels, only minimal air is present[24]. In some cases, small amounts of free air can be missed (Figure 4). Viewing the images at wide window settings (i.e., lung or bone windows) can optimize detection of free air (Figure 5)[25].

Sometimes, air in the peritoneum is not related to the bowel injury but results from caudad dissection of air from traumatic injuries of the thorax, mechanical ventilation, bladder rupture with Foley catheter placement or diagnostic peritoneal lavage performed prior to CT (Figure 6)[24]. Foci of free air seen adjacent to a thickened bowel loop or in association with mesenteric fat stranding or extraluminal fluid, increases the probability of bowel injury. Isolated finding of free air in the abdomen should raise other possibility of pneumoperitoneum as listed above.

ORAL CONTRAST EXTRAVASATION (EXTRALUMINAL CONTRAST MATERIAL)

The routine use of oral contrast media in trauma patients is controversial. Some studies showed that CT scan performed without oral contrast is adequate for the evaluation of patients with blunt abdominal injury and oral contrast media is rarely of benefit in the diagnosis of acute bowel injury[14,24,26,27]. Others have claimed that this practice is unnecessary and potentially dangerous[19]. Administration of oral contrast prior to CT scan may delay the examination and has a risk of aspiration. However, many centres still continue to practice the administration of oral contrast to patients prior to CT scanning[19]. Oral contrast material has been shown to be useful in depicting injuries of the duodenum and proximal jejunum as well as pancreatic and mesenteric injuries. Opacification of bowels make mural and interloop haematomas more easily recognized[19]. Furthermore, there were no reported significant complications related to contrast administration in many previous series[19,24,28].

Extravasation of oral contrast from the bowel lumen is a specific sign of bowel perforation but the finding is quite uncommon (Figure 7)[24]. It is reported to present in 6% to 8% of patients with bowel and/or mesenteric injuries[2,14]. The low sensitivity of this finding may be due to scanning before oral contrast has reached the site of perforation or dilution of the small amount of extravasated oral contrast into the larger amount of free peritoneal fluid. False-positive finding can occur in patients with contrast leaking from a urinary tract injury.

BOWEL WALL THICKENING

Bowel wall is considered to be abnormally thick if it measures at least 3mm (small bowel) and 5mm (large bowel) or clearly disproportionate to normal bowel wall segments. Differentiating normal and abnormal bowel wall segments is often better with 'eye-balling' than strict direct measurement (Figure 8 and Figure 9)[24].

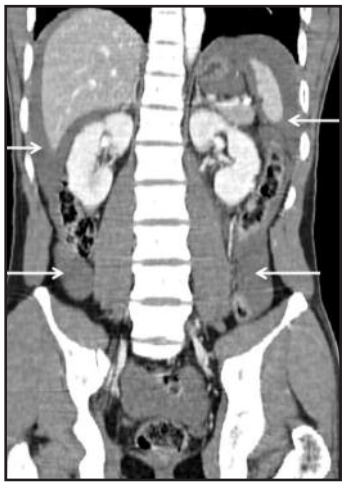

Fig. 1: Coronal CT abdomen. Massive haemoperitoneum from bowel and mesenteric injuries. Free fluid collection in perihepatic, perisplenic and paracolic gutters (arrows) in a patient with perforated jejunum, mesenteric tear and mesenteric contusions. Intraoperative blood loss was reported to be 1200mL. Small bowel resection with end-to-end anastomosis was done and this patient recovered well.

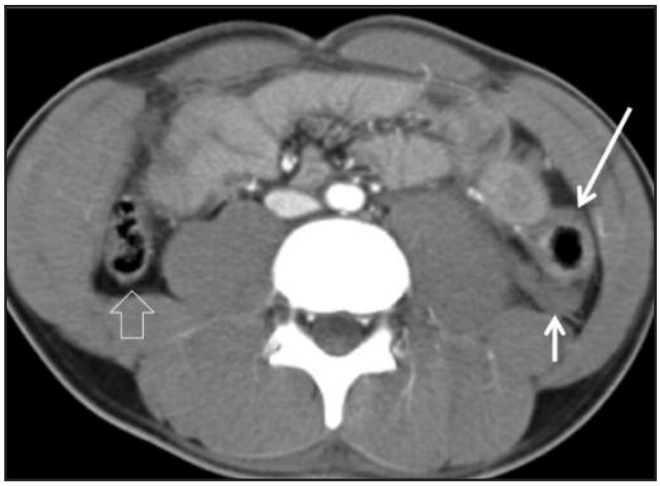

Fig. 2: CT abdomen of a 23-year-old patient who was trapped in a lorry following a motor vehicle accident. Injury to the descending colon was suspected in view of fluid collection at the left retroperitoneum (short arrow) and a thickened colonic wall (long arrow). Compare to the normal fat density surrounding the right ascending colon (open arrow). Serosal tear of the descending colon was proven at surgery.

Fig. 3: Axial CT abdomen illustrating free air under the diaphragm (arrows) from perforated small bowel in a 29-year-old motorcyclist following a road accident.

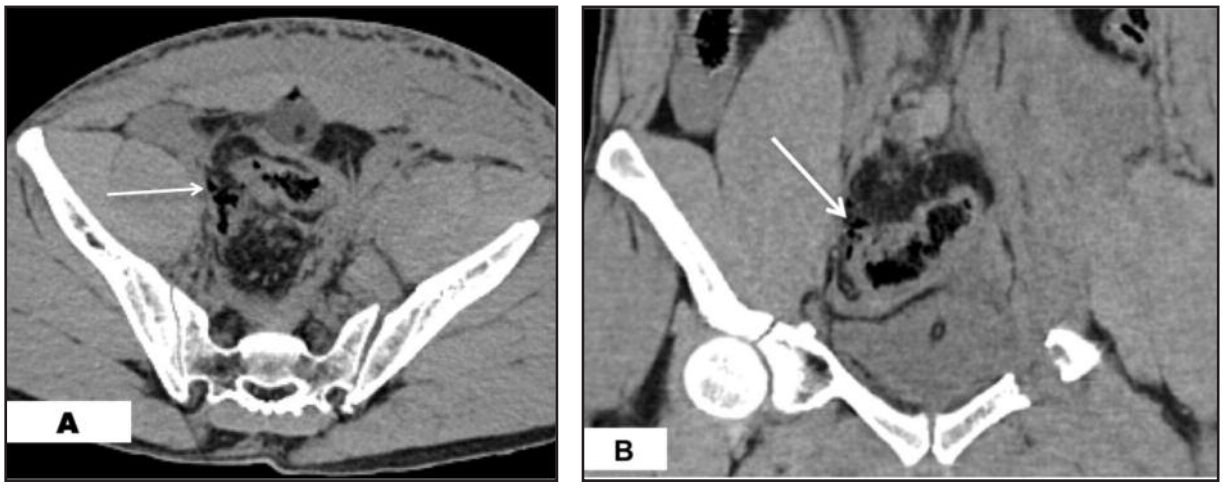

Fig. 4(A & B): Small extraluminal air from a transected rectosigmoid colon. 26-year-old man whose lower abdomen was hit by a falling metal pipe at a factory. Bowel injury was missed on CT scan. Retrospective review of the CT scan in soft-tissue window axial view (A) and coronal MPR (B) showed a subtle extraluminal air (arrow).

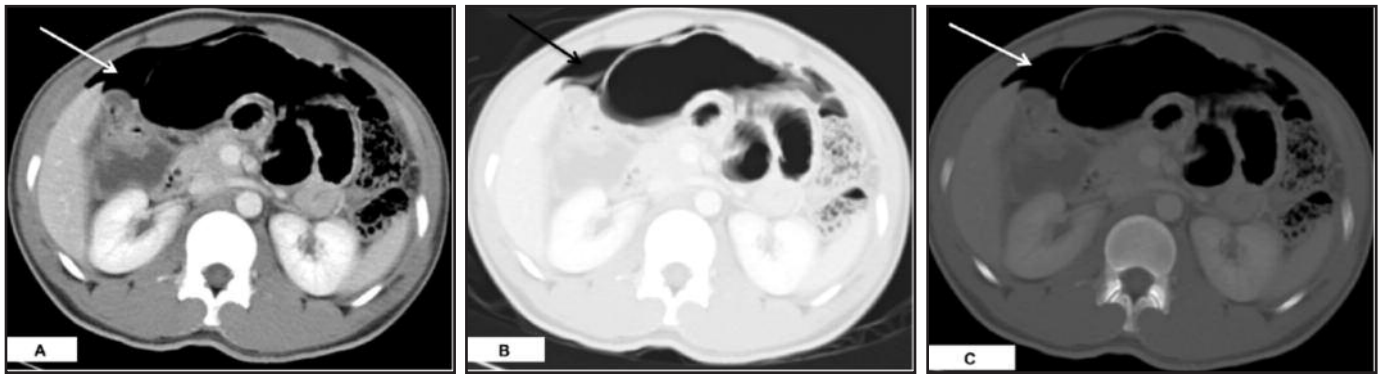

Fig. 5 (A-C): Pneumoperitoneum reviewed with different CT window. Axial CT scan in a patient with small bowel injury. The images are taken at same level and sequence, but reviewed using (A) soft tissue window, (B) lung window and (C) bone window. The extraluminal air (arrow) is best seen using lung window setting.

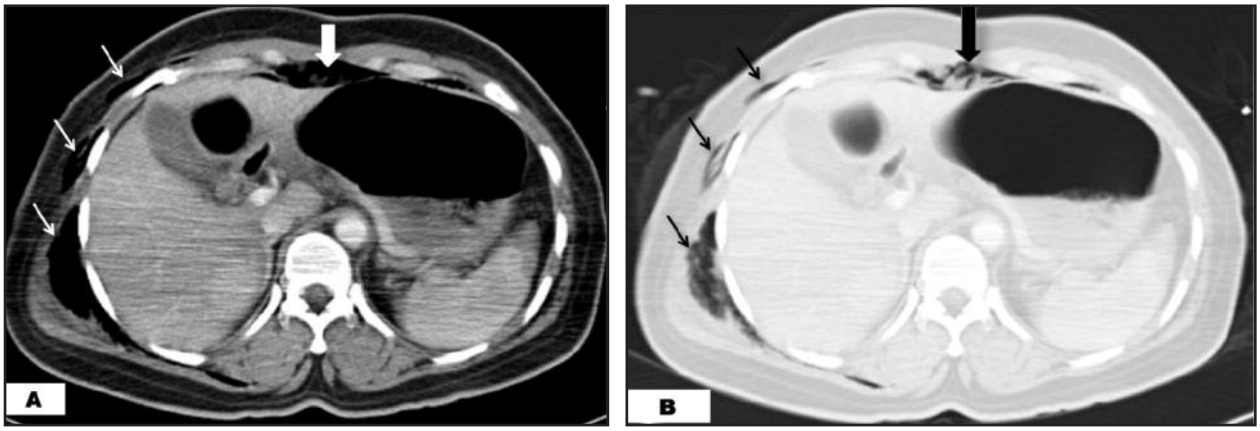

Fig. 6 (A & B): Pseudopneumoperitoneum from extensive thoracic injuries. A 37 year old lady who sustained multiple and bilateral ribs fracture with flail chest and haemopneumothoraces following a road accident. Axial CT abdomen (A) soft tissue window and (B) lung window, showed air collection anterior to the stomach (broad arrow). Note the extensive subcutaneous emphysema (short arrow). She had no intra-abdominal injury and no haemoperitoneum.

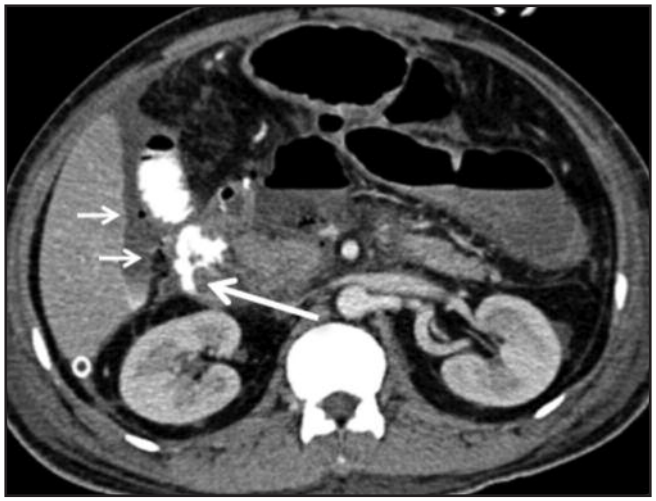

Fig. 7: Axial CT abdomen showed extravasation of oral contrast (long arrow) from transected duodenum in this 39-year-old patient who was involved in a motor vehicle accident. Air pockets were also seen within the haemoperitoneum (short arrows) adjacent to the injured bowel loop.

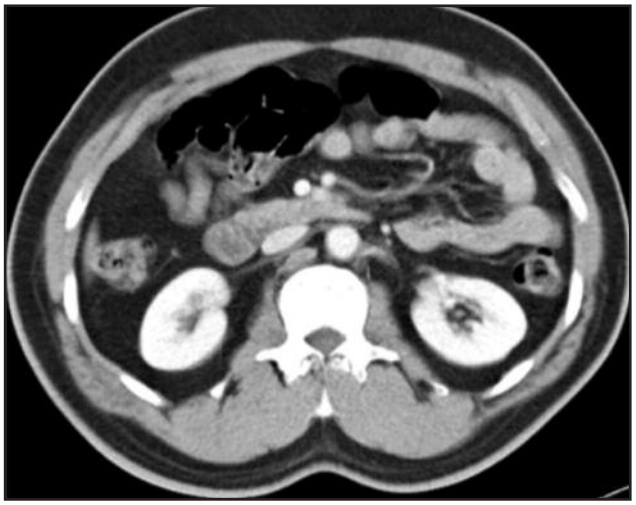

Fig. 8: Normal bowel loops in patients with blunt abdominal trauma who had solid organ injury but no bowel and mesenteric injury.

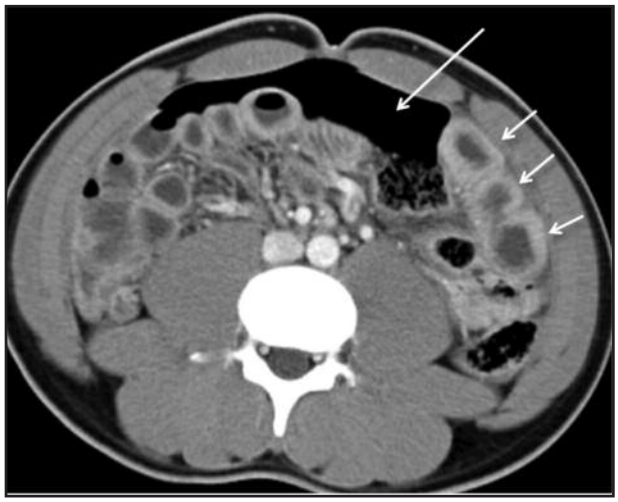

Fig. 9: Axial CT abdomen demonstrating bowel wall thickening in a patient with small bowel injury. An 18-year-old man, whose motorcycle skidded. The small bowels are dilated and the walls are thickened (short arrows). Note the massive pneumoperitoneum (long arrow).

Fig. 10: Generalized small bowel thickening (short arrows) with abnormal intense enhancement in a hypotensive patient. This 19-year-old man sustained Grade III liver injury (image not shown) and Grade IV renal injury with massive haemoperitoneum. He had 3L blood loss and no bowel and mesenteric injury was detected intraoperatively. In this axial CT abdomen, notice the massive right perinephric haematoma (open arrow), flat IVC (long arrow) and intense enhancement of both kidneys.

Fig. 11: Axial CT abdomen showed a focal small bowel thickening with abnormal enhancement (long arrow) in a patient with non-viable ileum secondary to a mesenteric injury. Compare with part of the small bowel with no bowel wall thickening (short arrow).

Fig. 12: A 21-year old motorcyclist who collided with another motorcyclist. He had laceration to the jejunum with mesenteric tear. Axial CT abdomen showed irregularity of mesenteric vessels (arrows).

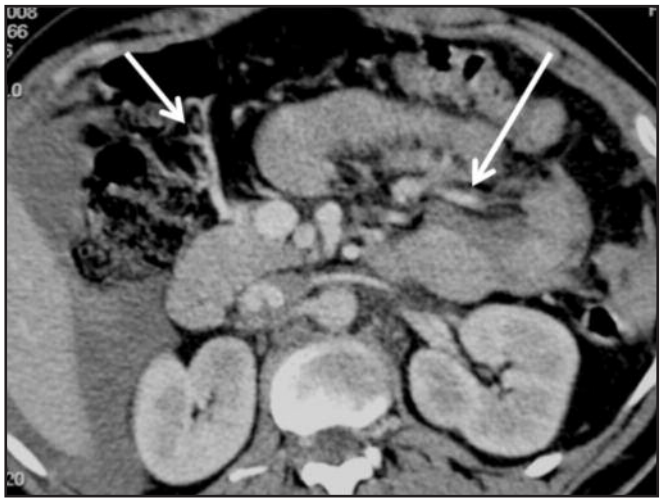

Fig. 13: CT abdomen shows abrupt mesenteric vessel termination (long arrow), compare to normal tapering of mesenteric vessel (short arrow). This patient had non-viable ileum due to multiple mesenteric tear. Resection of the non-viable ileum was performed with end-to-end anastomosis of the bowel loops.

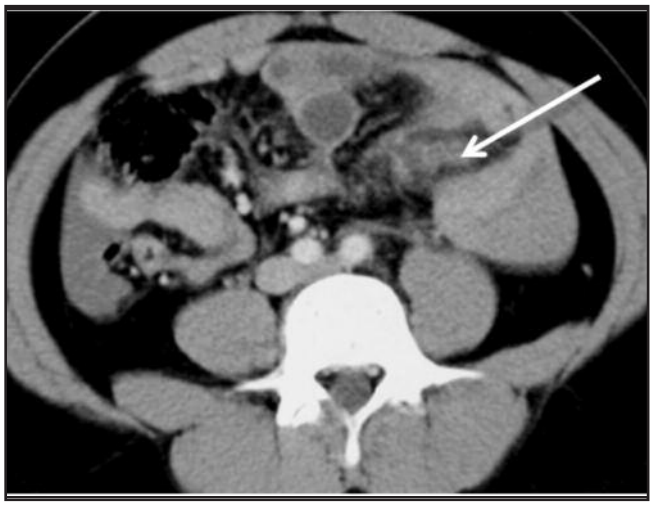

Fig. 14: 29 year-old-man, who was injured in a motor vehicle accident. CT abdomen showed mesenteric streakiness and fluid collection (arrow). Intra-operative findings of mesenteric tear were detected at multiple sites.

Isolated, localized, unequivocal bowel wall thickening is associated with a high likelihood of bowel injury that requires surgical repair[24]. The injured bowel may demonstrate circumferential or eccentric wall thickening. Small bowel wall thickening had a sensitivity of 45-50% and specificity of 76-84% in the diagnosis of surgically important bowel and/or mesenteric injuries[16]. Large bowel wall thickening had a higher specificity of 97% in detecting bowel and/or mesenteric injuries[14].

Diffuse small bowel thickening is atypical for acute contusion and may represent bowel oedema secondary to hypoperfusion complex (shock bowel). Hypoperfusion complex is usually associated with other findings of shock such as flat inferior vena cava, diminished aortic caliber and increased enhancement of organs such as adrenal glands and pancreas (Figure 10). However, systemic volume overload due to fluid resuscitation in these patients may manifest as bowel thickening alone. Diffuse bowel wall thickening is also seen in delayed perforation due to generalized peritoneal inflammation.

ABNORMAL BOWEL WALL ENHANCEMENT

Abnormal bowel enhancement is defined as increase or decrease in enhancement of bowel wall compared to enhancement of adjacent bowel loops (Figure 11). Increased bowel wall enhancement may represent bowel injury with vascular involvement or may be part of the hypoperfusion complex. Patchy or focal increase in bowel wall enhancement is suggestive but not diagnostic of full-thickness injury. On the other hand, areas of decreased or absent contrast enhancement are indicative of ischaemic bowel. Lack of enhancement was seen in 13% of patients with bowel and mesenteric injuries[2]. This finding, like bowel wall thickening mandates careful follow up if seen as an isolated finding. It is usually accompanied by several other suggestive or diagnostic CT findings of significant bowel injury of clinical findings mandating exploration.

BOWEL WALL DISCONTINUITY OR DEFECT

Direct visualization of bowel wall defect due to perforation is uncommon. It may be present in 7% of patients with bowel and mesenteric injuries[2]. The use of thin section, multi-slice spiral CT should increase its recognition by decreasing motion and volume averaging. CT sign of bowel wall discontinuity had sensitivity of 58% and specificity of 95%[16].

MESENTERIC EXTRAVASATION

Extravasation of mesenteric vascular contrast medium is 100% specific for the diagnosis of significant mesenteric injuries[2]. However, it is relatively uncommon and is seen in only 17% of patients with bowel and mesenteric injuries[2,19]. A finding of mesenteric extravasation is usually an indication for urgent laparotomy. Variation in practice and technique may influence detection of some CT signs of injury such as mesenteric extravasation that needs fast contrast administration to maintain vascular opacification.

MESENTERIC VASCULAR BEADING AND ABRUPT TERMINATION OF MESENTERIC VESSELS

These are two new signs in bowel and/or mesenteric injuries that indicate vascular injury[14]. Mesenteric vascular beading appears as irregularity in mesenteric vessels (Figure 12). It was reported in 39% of patients with bowel and/or mesenteric injuries. Abrupt termination of mesenteric vessels is seen in 35% of patients with bowel and/or mesenteric injuries (Figure 13)[2]. Combination of these two signs showed the best sensitivity and specificity and is seen in 60% of patients with surgically important mesenteric injury[14].

MESENTERIC INFILTRATION

Mesenteric infiltration is seen on CT as area of inhomogenous increased attenuation within the mesentry (Figure 14). It is also known as mesenteric stranding. Mesenteric stranding and fluid at mesenteric root are frequently seen together. Mesenteric infiltration may indicate mesenteric injury with or without bowel injury. It is the

commonest changes seen with sensitivity of 69%, but is nonspecific (44%) and does not indicate a need of surgery[16,24]. Mesenteric abnormalities seen in combination with focal bowel wall thickening are associated with high likelihood of an injury that requires surgical repair[24].

MESENTERIC HAEMATOMA

Mesenteric haematoma is seen as well-defined mass on CT scan[24]. The sensitivity and specificity of mesenteric haematoma in the diagnosis of surgically important bowel and/or mesenteric injuries were 45-54% and 90-94% respectively[14,16]. There may be associated bowel ischaemia or infarction due to disruption of blood flow, which causes bowel wall thickening in the absence of perforation. Although specific to mesenteric injury, mesenteric haematoma does not always indicate a need for surgery[24]. In the absence of other CT or clinical signs of bowel perforation and infarction, a patient with isolated mesenteric haematoma can be potentially treated conservatively.

CONCLUSIONS

CT examination is not only expected to be accurate in diagnosing bowel and/or mesenteric injuries in patients with blunt abdominal trauma but also to differentiate those with surgically significant from non-surgically significant injuries. Differentiation of these two conditions may not always be possible due to some overlap between the CT features of both conditions that compromises specificity. Re-evaluation with MSCT within 6-8 hours after the initial evaluation and clinical correlation has been found to be helpful to elucidate the significance of such findings.

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MCQ (TRUE/FALSE)

1. The following statements are true regarding CT of bowel and mesenteric injury in blunt abdominal trauma.
a. CT scan is the imaging modality of choice in assessing haemodynamically unstable patients with blunt trauma suspected to have bowel and mesenteric injury.
b. CT scan finding is useful to guide the subsequent patient management.
c. Oral contrast media should be given for adequate assessment of bowel and mesenteric injuries on CT scan.
d. CT scan is highly sensitive for the detection of duodenal injuries.
e. Follow-up CT is recommended for monitoring patient's recovery in all cases with conservative management.

2. The following statements are true regarding bowel and mesenteric injuries in blunt abdominal trauma.
a. The current trend in management of injuries is surgery in all cases.
b. Clinical signs can be elicited in less than 10% of cases.
c. Bowel and mesenteric injuries are common.
d. CT scan should be repeated after 3 days if there is clinical suspicion of injuries but negative initial scan.
e. Hypoperfusion complex (shock bowel) is demonstrated as focal bowel wall thickening on CT scan.

3. The following statements are true regarding diagnostic tests used in bowel and mesenteric injuries in blunt trauma.
a. DPL is more sensitive than ultrasound in detecting haemoperitoneum in these patients
b. DPL is highly sensitive and specific to diagnose and localize the injuries.
c. DPL may miss up to 70% of bowel injuries.
d. Ultrasound is accurate in diagnosing bowel and mesenteric injury.
e. FAST has high sensitivity in the detection of haemoperitoneum in these cases.

4. The following statements are true regarding CT findings of blunt bowel and mesenteric injuries.
a. Pneumoperitoneum is pathognomonic of bowel perforation.
b. Pneumoperitoneum has high specificity but low sensitivity in diagnosing bowel injuries.
c. Extravasation of oral contrast is highly sensitive in detection of bowel injury.
d. The presence of free fluid is the most sensitive features of bowel and/or mesenteric injury.
e. Diffuse small bowel wall thickening is typical for acute bowel contusion.

5. The following statements are true regarding CT imaging of mesenteric injuries
a. Demonstration of mesenteric haematoma indicates need of surgery in many cases.
b. Mesenteric infiltration is the most specific sign of mesenteric injury.
c. Extravasation of mesenteric vascular contrast is specific for the diagnosis of significant mesenteric injury.
d. Mesenteric contrast extravasation is commonly seen in these patients.
e. Abrupt termination of mesenteric vessels and vascular beading are signs of non-significant mesenteric injury.